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Radiative Transfer of Lightning Light by Thundercloud and Applications to Imaging and Photometric Observations

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Thunderstorms occur all over the world, and produce flashes (optical and radio waves). From space, only the light scattered by the cloud is visible. Understanding the radiative transfer of light produced by the lightning discharges in the clouds is therefore fundamental. Observations made by low orbit satellites for twenty years gave the first global map of electrical activity of thunderstorms. Many on-board instruments can now detect lightning. For the first time, the current generation of geostationary meteorological satellites is equipped with lightning imagers. These satellites strongly contribute to the real-time alert of severe weather associated with thunderstorms. Simultaneously, the ASIM mission on board the International Space Station, can measure lightning at different wavelengths, from near-UV to near-IR (imagery and photometry) and provide complementary measurements to those of the geostationary satellites.

The present study aims to better quantify the radiative transfer of the light emitted by lightning discharges through the cloud. We characterize optical lightning waveforms and images detected by satellites with three-dimensional simulation of photons transport through clouds. A forward three dimensional radiative code based on a Monte-Carlo approach (Cornet et al., 2010) is used in order to accurately simulate the scattering/absorption processes by cloud particles and molecules. The light emitted by the lightning source is simulated as a large number of photons with different temporal and spatial distribution. The simulations have been done for different wavelengths from the near-UV to the near infra-red close to those observed by the ASIM mission. Simulation results are compared to previous results from Light et al. (2001) and Luque et al. (2020) in the case of simple homogeneous water clouds. Furthermore, a sensitivity study is presented concerning the effect of the position, vertical extension and temporal character of the emitting source as well as the cloud microphysics on the signal observed at the top of the atmosphere.

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